

Artificial Neural Networks in Forensic Medicine (review)

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Abstract

The article deals with the possibilities and limitations of the use of artificial neural networks in forensic medical practice. It is known that in the work of forensic medicine experts have to process and evaluate a large amount of information, which may belong to different types of data - the site inspection protocols, photographic materials, macroscopic data obtained during the autopsy of the corpse, the results of laboratory tests, medical records etc. All the received data should be studied, categorized and evaluated according to international standards. Modern computer technologies of artificial intelligence (artificial neural networks) can help in the handling of forensic medicine data, which, in turn, will reduce to a minimum the probability of mistakes in preparation of expert conclusions. The algorithms used in artificial neural networks, as a result of processing different types of input data, can direct them to the resulting categorized outputs and structure them.

Keywords : *artificial neural networks, artificial intelligence, forensic medicine, identification of a person.*

Introduction

Recently, more and more researchers are using artificial intelligence elements in their practice. [1, 2] There are discussions whether the machine intelligence can replace doctors. [3] The scientific community converges in opinion, that in the nearest future this will not happen, but artificial intelligence could help doctors to make better decisions or even partially displace human judgment in certain narrow areas. The growing amount of data that can be used in medical practice, as well as the analytical methods used in their processing, allow us to give successful examples of the use of artificial intelligence in medicine. [4,5,6] These algorithms are used in such areas like cardiology, dermatology, immunology, oncology, dentistry, genetics and so on. [1- 8] Elements of artificial intelligence begin to apply in

forensic medicine. [9 -12]

The purpose of this work is to analyze the possibilities and limitations of the use of artificial neural networks in forensic medical practice (Fig. 1

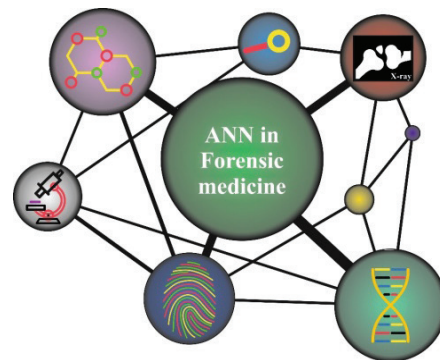


Fig. 1 . The fields of possible application of ANN in forensic medicine.

Artificial neural networks.

Artificial neural network (ANN) -is a mathematical model, which in its structure is similar to the human nervous system. In the same way as the human being, ANN can learn and generalize knowledge. That is why ANN is refers to artificial intelligence. ANN is widely used in all fields of science and technology, and you

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even use it every day entering Facebook or looking for information in Google. There are many different types of ANN, which are concentrated on solving of the certain types of problems. [13]

In general, ANN is a system of connected and interacting processors (neurons). A neuron (the base element of ANN) is a simple computing processor that can receive, process and transmit the information. By combining a large number of neurons into a single network, the system can solve non-trivial tasks.

Neurons in ANN are combined in layers (Fig. 2) - the input layer (a set of neurons that receive information), n-hidden layers (the set of neurons, which will process the information), and the output layer (neurons which outputs the result).

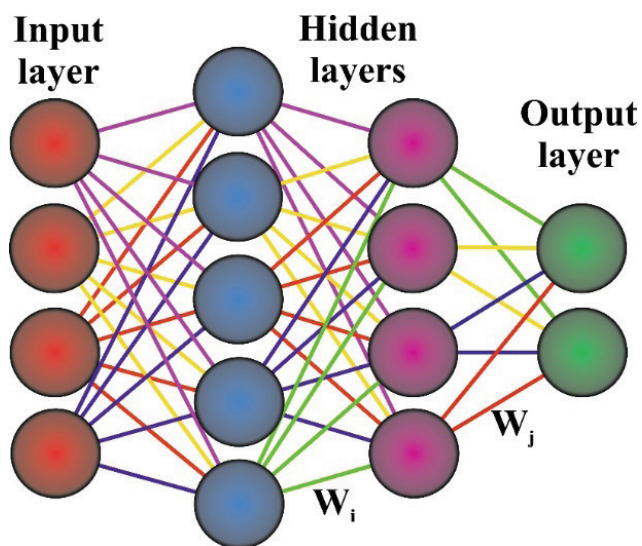


Fig. 2 .The Structure of the neural network.

During the operation, neurons operate with numbers. Usually these numbers are in the range [0,1] or [1,1]. Each neuron has two parameters: input data and output data. The field of input data contains the summary information from all the neurons of the previous layer. After receiving the information, it is normalized by the activation function $f(x)$, after which it falls into the field of output data. It should be noted, that for the input layer of neurons input information is equal to the output information (input = output).

All the neurons are integrated into the network with the help of synapses (Fig. 2, W_i, W_j). A synapse is a connection between two neurons that is characterized

by the weight of the synapse. [14] Due to the weight of the synapse, the input information changes during the transmission from one neuron to another. In Fig. 3 it is shown how the synapse weight can change the data in colors. During processing of the input data will be obtained the result in which the most important role will play the synapse with the most weight. The combination of all the weights of the synapse neurons allows the system to make the decisions. Depending on the complexity of the task, the number of neurons and layers can change a lot.

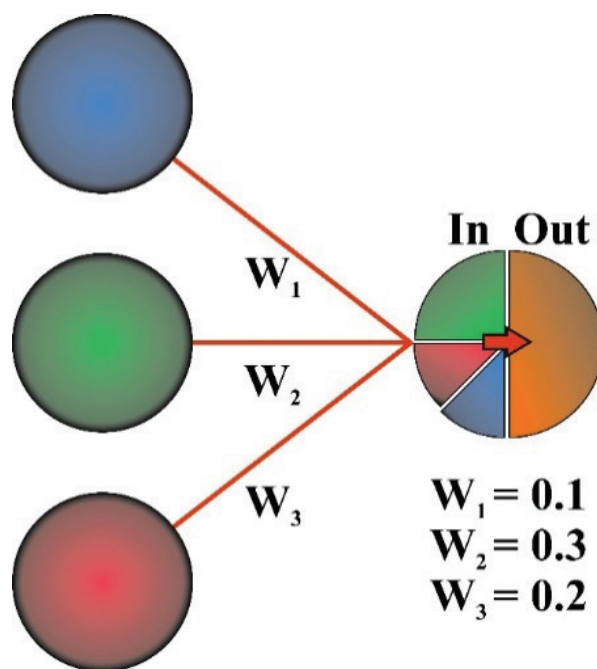


Fig. 3. Given the neural result of the processing of data by a neuron by the weight of synapses.

Another important element of the neural network is a function of activation (activation functions [15]) - the function which normalizes the input data (the function which allows you to interpret data in the form of numbers, belonging to the range [0,1]). In this activation function for determination of the output data, the total sum of input data and weight coefficients are compared with some threshold. If the sum is greater than the threshold, the processing element generates a signal, otherwise the signal is not generated (or a brake signal is generated). [16] The most common practice is the using of the sigmoid function (Fig. 4). An important feature of sigmoid is the continuity of functions and their derivatis.

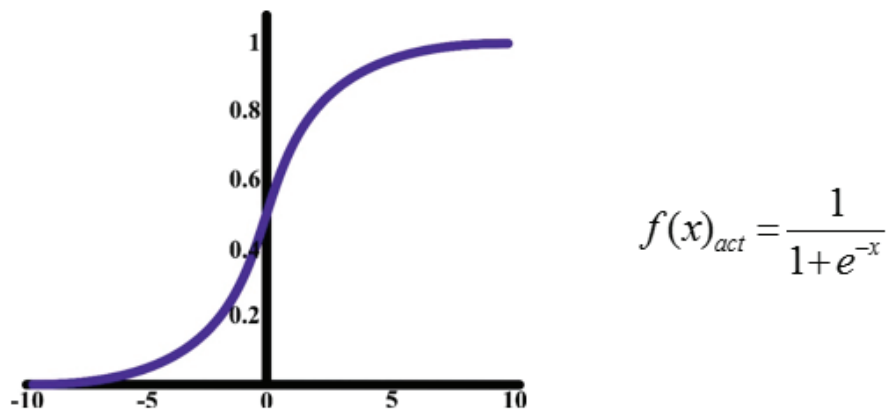


Fig. 4. Nonlinear activation function that approximates the minimum and maximum values in asymptotes.

In order the ANN could work, it must first be trained. Training is usually conducted on the databases with relevant input and output data. The data basis consists of already known cases and conclusions to them. Data can be both numeric and non-numeric. In the case of non-numerical data, they need to be structured by certain we categories.

Table1. The example of the input data table for teaching ANN. The order number corresponds to a certain person. Data_{ji} - data, fixed in a specific case and grouped into appropriate categories.

N	Data				Result
1	Data 1 1	Data 12	...	Data 1i	Result 1
2	Data 21	Data 22	...	Data 2i	Result 1
3	Data 31	Data 32	...	Data 3i	Result 2
...
j	Data j1	Data j2	...	Data ji	Result 1

The filling of the table can be illustrated by identifying racial affiliation of unknown male person. Table 2.

Tab. 2: The example of filling the table with data to identify the race of unknown male person.

N	Skin color	Eye color	HairColor	...	Growth	Result
1	Yellow	Hazel	Black	...	167	Asian
2	White	Blue	Blond	...	178	Europeoid
3	Yellow	Hazel	Black	...	175	Asian
4	White	Hazel	Black	...	180	Europeoid
..
j	Yellow	Hazel	Black	...	174	Asian

Software for ANN building

The power of modern computers allows to process rather difficult tasks even on the non-specialized devices. Experts can create and train ANN on conventional computers, using common software. There are many software packages available to work with ANN. [17] Most of them are focused on the experienced user, who has programming skills.

Among the software with the low entering barrier can be noted the Statistica. [18] This program allows you quickly build ANNs of different architecture and complexity. It is also important that after teaching ANN in this software, you can immediately conduct researches on new data and instantly get results.

The practical use of ANN

In its practice, forensic expert faces with many challenges of different complexity. Some of these tasks can be facilitated by the use of artificial intelligence.

DNA studies

Genetic identification is one of the main modern methods of analysis in forensic medicine. Thus, the researches of electropherograms are held in a huge quantity in forensic DNA laboratories. Genetic experts should be involved in the correct interpretation of the obtained data. [19]

In the work [20], we can see data concerning the using of ANN for the identification and classification of peaks in the electropherogram. The authors note that the process of interpretation of the electropherogram can be time consuming and depends on the subjective evaluation of the analyst. These works show the possibility of using artificial neural networks for reading complex and mixed electrophoretic data. Thus, the use of ANN can simplify processing and improve the accuracy of DNA testing.

Authors [21] showed the possibility to determine the age of the donor with the restored biological material, using the methods of DNA analysis and ANN. This information can be of considerable value for forensic investigations. The authors claim that aging is a complex process, associated with different molecular modifications in cells that re accumulated throughout the

life, caused by genetic and epigenetic factors. In order to generate the accurate model for predicting chronological age, the authors used age-specific DNA methylation models from the data of whole blood. Because of data processing using ANN, authors achieved a good prediction result with a 4-year error on the blind test.

Firearms

Another possible application of ANN in forensic medicine is to establish the similarity of the balls, fired from the firearms. Thus, in the work [22] it is showed, how ANN can be used in the study of bullet tracks. The above-mentioned work ANN studied on the well-known data bases, and then made the processing of unknowns balls. As a result, the network showed very good results of comparison on the test sample.

Causes of death

Often in practice, we have cases when it is quite difficult to establish direct relationships between diseases and death, especially in the partial or complete absence of medical records of a person. The authors [23] use an ANN for classifying cause of death from verbal autopsy. The efficiency of ANN models was compared with two other classification methods (physician examination and logistic regression) that were tested on the same sample with the same verbal autopsy data. As a result, the comparisons of ANN models were as accurate as the other methods used.

Pharmaceutical fingerprinting

ANN can be also successfully applied in laboratory analyzes of chemical substances. Work [24] shows the possibility of ANN application in forensic toxicology. Thus, authors made chromatogram medicines investigations in biological fluids and compared them with the reference samples. The result shows that the received ANN can provide fast, accurate and consecutive technique, applied for searching of the chemical agents in biological fluids.

In the work of Zhu H., the potential possibilities of ANN application for drugs investigation are showed. It is noted that artificial intelligence is a promising method to greatly reduce the cost and time of drug discovery

by providing evaluations of drug molecules in the early stages of development. [25]

Investigation of bones and teeth

ANNs can be successfully used in identifying an unknown person on cystic fragments. Thus, in the work [26] the authors use ANN during the determination of the gender and age of the unknown person according to the odontological parameters of the jaws. They point out that the use of ANN is promising because automates and simplifies the method of sex and age installation with minimal errors. In the works [27,28] the possibility of using ANN in the teeth and bones research is explored.

Fingerprints

The research of the fingerprints is one of the basic identification methods in forensic medicine. In the works [29-30] the possibility of classifying fingerprints with the help of ANN is investigated. Built ANN allowed to reduce the time of image processing. The authors [31] proposed the method of comparing fingerprints, including partial (incomplete) images. In the works [32,33] authors use fingerprints for predicting sexual identity. The ANNs made it possible to classify gender with a probability of 97 %.

Of course, the practical application of ANN is not limited to these examples. Currently, there are prerequisites for the application of ANN in practically every field of forensic medicine. The main problem, which may face a forensic expert in choosing this method of research is the content of database for network training. It is also required that expert should understand fundamental statistical and mathematical methods.

Conclusions

As noted earlier, ANN can be applied practically in any section of forensic medicine. Their advantages are the ability to process large amounts of data, less likely missing of critically important data, and reducing decision time. Yet, at this stage we cannot do without human control. ANN is necessary, first of all, as a helper or tool, which is designed to help in making difficult decisions. But in any case, it does not diminish the potential benefit, which can provide the skillful use of

elements of artificial intelligence.

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